

WHAT IS CLAIMED IS:

- 1 1. A virtual storage system comprising:
2 a computing device accessing virtual storage;
3 a plurality of physical storage devices; and
4 a controller in communication with the computing device and the
5 plurality of physical storage, the controller operative to
6 (a) receive a virtual storage access request from the computing
7 device specifying a virtual data access, the virtual data access
8 comprising a plurality of blocks, each of the plurality of
9 blocks associated with one of at least two target physical
10 storage devices, the target physical storage devices
11 comprising at least a subset of the plurality of physical
12 storage devices;
13 (b) determine an access sequence associating one target storage
14 device with each block in the received virtual storage access
15 request;
16 (c) send at least one physical access request to each target
17 storage device;
18 (d) receive at least one error message from at least one target
19 storage device, each error message having an error type; and
20 (e) determine an error response based on the error message type
21 and on the access sequence.
- 1 2. A virtual storage system as in claim 1 wherein received error
2 message types comprise communication error and access error.
- 1 3. A virtual storage system as in claim 1 wherein the determined
2 error response comprises terminating the virtual storage access if the received error
3 type comprises a communication error.
- 1 4. A virtual storage system as in claim 1 wherein the determined
2 error response comprises terminating each physical access request corresponding to

3 a block in the access sequence later then a problematic block, the problematic block
4 one of the plurality of blocks an attempted access of which generates at least one
5 error message.

1 5. A virtual storage system as in claim 4 wherein the virtual
2 storage access comprises a read operation from the computing device, the controller
3 returning to the computing device blocks in the access sequence prior to the
4 problematic block.

1 6. A virtual storage system as in claim 1 wherein the determined
2 error response comprises terminating each physical access request corresponding to
3 a block in the access sequence later then a problematic block, the problematic block
4 one of the plurality of blocks an attempted access of which generates a
5 communication error.

1 7. A virtual storage system as in claim 6 further comprising
2 returning an indication of an access error to the computing device.

1 8. A virtual storage system as in claim 1 wherein the determined
2 error response comprises terminating each physical access request corresponding to
3 a block in the access sequence later then a problematic block, the problematic block
4 one of the plurality of blocks an attempted access of which generates an access
5 error.

1 9. A virtual storage system as in claim 1 wherein the error
2 response includes an indication of the first block in the access sequence the access
3 of which generates an error message.

1 10. A method of servicing a virtual storage request placed by a
2 computing device, the virtual storage request specifying a plurality of blocks, the
3 blocks distributed between at least two physical target storage devices, the method
4 comprising:

5 determining an access sequence associating one target storage device
6 with each block in the virtual storage request;
7 sending at least one physical access request to each target storage
8 device;
9 receiving at least one error message, each error message sent from
10 one target storage device, each error message having one of a plurality of error
11 types; and
12 determining an error response based on the error type for at least one
13 error message and on the access sequence.

1 11. A method of servicing a virtual storage request as in claim 10
2 wherein the error types comprise a communication error and an access error.

1 12. A method of servicing a virtual storage request as in claim 10
2 wherein the error message has a communication error type indicating the target
3 storage device sending the error message is unavailable, the error response
4 comprising terminating each physical access request for all target storage devices.

1 13. A method of servicing a virtual storage request as in claim 10
2 wherein the error message has an access error type indicating the target storage
3 device cannot access a problematic block, the error response comprising terminating
4 each physical access request for any block in the access sequence after the
5 problematic block.

1 14. A method of servicing a virtual storage request as in claim 13
2 wherein the virtual storage request is a read request, the error response further
3 comprising sending to the computing device all blocks in the access sequence before
4 the problematic block.

1 15. A method of servicing a virtual storage request as in claim 10
2 wherein the error message has a communications error type, the error response
3 comprising terminating each physical access request for any block in the access
4 sequence after the problematic block.

1 16. A method of servicing a virtual storage request as in claim 15
2 wherein the virtual storage request is a read request, the error response further
3 comprising sending to the computing device all blocks in the access sequence before
4 the problematic block.

1 17. A method of servicing a virtual storage request as in claim 10
2 wherein determining an error response comprises:
3 determining a first problematic block in the access sequence as the
4 first occurring block in the access sequence the attempted access of which returned
5 an error message; and
6 returning an indication of the first problematic block to the computing
7 device placing the virtual storage request.

1 18. A method of servicing a virtual storage request as in claim 10
2 wherein determining an error response comprises:
3 determining as a first problematic block the first block in the access
4 sequence the access attempt of which generated an error message;
5 determining the error type for the first problematic block; and
6 forwarding the determined error type to the computing device placing
7 the virtual storage request.

1 19. A method of servicing a virtual storage request as in claim 10
2 wherein determining an error response comprises:
3 determining as a first problematic block the first block in the access
4 sequence the access attempt of which generated an error message;
5 determining the error type for the first problematic block as a
6 communication error; and
7 forwarding an access error type message to the computing device
8 placing the virtual storage request.

1 20. A method of servicing a virtual storage request placed to a
2 virtual storage device, the virtual storage request comprising a logical sequence of

3 a plurality of blocks stored on a plurality of physical storage devices, the physical
4 storage devices comprising the virtual storage device, the method comprising:
5 placing at least one physical storage request to each of the plurality
6 of physical storage devices, each physical storage request requesting access to at
7 least one of the plurality of blocks stored on the physical storage device targeted by
8 the physical storage request;
9 receiving a response from each targeted physical storage device
10 corresponding to each physical storage request, each response comprising a
11 successful response or an error response, the error response indicating an error type;
12 for each error response, determining if the error type is an access
13 error, the access error indicating the targeted physical storage device could not
14 access a problematic block, the problematic block requested in the corresponding
15 physical storage request; and
16 if the error type is an access error, canceling all active physical
17 storage requests later in the logical sequence than the problematic block.

1 21. A method of servicing a virtual storage request as in claim 20
2 further comprising canceling all active physical storage requests if the error type is
3 a communication error indicating the targeted physical storage device receiving the
4 corresponding physical storage request is unavailable.

1 22. A method of servicing a virtual storage request as in claim 20
2 further comprising canceling any active physical storage requests later in the logical
3 sequence than the problematic block if the error type is a communication error
4 indicating the targeted physical storage device receiving the corresponding physical
5 storage request is unavailable.

1 23. A method of servicing a virtual storage request as in claim 20
2 wherein the virtual storage request comprises a read request, the method further
3 comprising forwarding to a computing device placing the virtual storage request all
4 blocks in the logical sequence prior to the problematic block.

1 24. A method of servicing a virtual storage request as in claim 20
2 further comprising returning an error indication comprising an indication of a first
3 problematic block, the first problematic block being the first block in the logical
4 sequence the access of which generates an error response.

1 25. A virtual storage system comprising:
2 a plurality of physical storage devices, each physical storage device
3 storing information as a plurality of blocks, each physical storage device responding
4 to a failed physical access request with an error message having one of a plurality
5 of error types; and

6 a controller responding to a virtual storage request for a sequence of
7 blocks stored on at least two of the physical storage devices, the controller operative
8 to

- 9 (a) determine an access sequence associating one physical storage
10 device with each block in the virtual storage request,
11 (b) send at least one physical access request to each physical
12 storage device listed in the access sequence,
13 (c) receive at least one error message from at least one of the
14 physical storage devices in the access sequence, and
15 (d) determine an error response based on the error type for at
16 least one error message and on the access sequence.

1 26. A virtual storage system as in claim 25 wherein the error
2 types comprise a communication error and an access error.

1 27. A virtual storage system as in claim 25 wherein at least one
2 received error message has a communication error type, each physical access
3 request for all physical storage devices in the access sequence terminated by the
4 controller.

1 28. A virtual storage system as in claim 25 wherein a received
2 error message has an access error type indicating the physical storage device sending
3 the received error message cannot access a problematic block, each physical access

4 request for any block in the access sequence after the problematic block terminated
5 by the controller.

1 29. A virtual storage system as in claim 28 wherein the virtual
2 storage request comprises a read request, the controller further returning all blocks
3 in the access sequence before the problematic block in response to the virtual storage
4 request.

1 30. A virtual storage system as in claim 25 wherein a received
2 error message has a communication error type, each physical access request for any
3 block in the access sequence after the problematic block terminated by the
4 controller.

1 31. A virtual storage system as in claim 30 wherein the virtual
2 storage request comprises a read request, the controller further returning all blocks
3 in the access sequence before the problematic block in response to the virtual storage
4 request.

1 32. A virtual storage controller for servicing a virtual storage
2 request placed to a virtual storage device, the virtual storage request comprising a
3 logical sequence of a plurality of blocks stored on a plurality of physical storage
4 devices, the virtual storage controller cancelling any requests to access blocks later
5 in the logical sequence than a problematic block the access of which generated an
6 access error, the virtual storage controller cancelling all requests to access blocks
7 after receiving a communication error from any physical storage device.